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3.3 LAKE OKEECHOBEE SERVICE AREA

3.3.1 Introduction

The Lake Okeechobee Service Area basins that are modeled as lumped basins in the SFWMM are simulated in a very different manner than that used for the gridded portions of the model (refer to Section 3.2). This section will detail the water budget approach utilized in the SFWMM by describing the implementation of the AFSIRS/WATBAL pre-processing tool. Additional topics in this section include special considerations on a basin by basin basis for the various non-EAA LOSA areas and an overview of the regional supply-side management policy that applies to the entire LOSA.

3.3.2 AFSIRS/WATBAL Model Overview

In the SFWMM, a consistent modeling approach is used to estimate lumped basin demands and runoff in all non-gridded portions of the SFWMM (refer to Figure 3.2.1.1). The AFSIRS/WATBAL model is the pre-processing tool used for this task. The model was developed for the Caloosahatchee Water Management Plan (CWMP) to estimate basin-scale, current and future water demand, and runoff (SFWMD, 2000). The model is based on and built around the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) model (Smajstrla, 1990). A short discussion of AFSIRS is presented in Appendix S. The generalized approach of this tool applies a water budget methodology to determine the "edge-of-basin" impact of a lumped area on the regional system. The primary components of the hydrologic budget including rainfall, ET, internal basin transfers and storage change (both in the soil column and detention storage) are all considered. The combined influences of these components are then translated on a daily basis to a net basin-scale runoff (source) or demand (sink) term, which is accepted by the SFWMM.

As an illustration of the AFSIRS/WATBAL modeling concept, consider an irrigated field in which soil moisture is at field capacity and no other local storage (ditches, etc.) outside of soil storage exists. In the successive time step, if rainfall occurs, this will be translated (after meeting local crop ET needs) to a volumetric discharge at the edge-of-field and will be resolved as "runoff". The excess water leaving the field would no longer be available within the control volume, but would impact the adjacent area (the regional system). Likewise, if there is no rainfall during the successive time step, crop ET will result in a depletion of water in the soil column. In order to maintain optimal plant yield, this deficit will be made up by pumping water from outside of the control volume into the field. This practice would be resolved as "demand" (a water-supply sink from the regional system). This simple example can be assumed to occur in several individual fields throughout a basin. The interactions between these individual fields takes place through a series of interconnected canals and detention areas in which carryover storage, transmission losses and incidental irrigation all become important factors in the water budget. All of these field scale and basin scale features are considered in the AFSIRS/WATBAL model. To further illustrate the tool's design, a conceptual diagram of the field-scale process representation, as applied in AFSIRS/WATBAL, is shown in Figure 3.3.2.1. The conceptual model for how individual field scale land uses is translated into basin scale demand and runoff is provided in Figure 3.3.2.2.

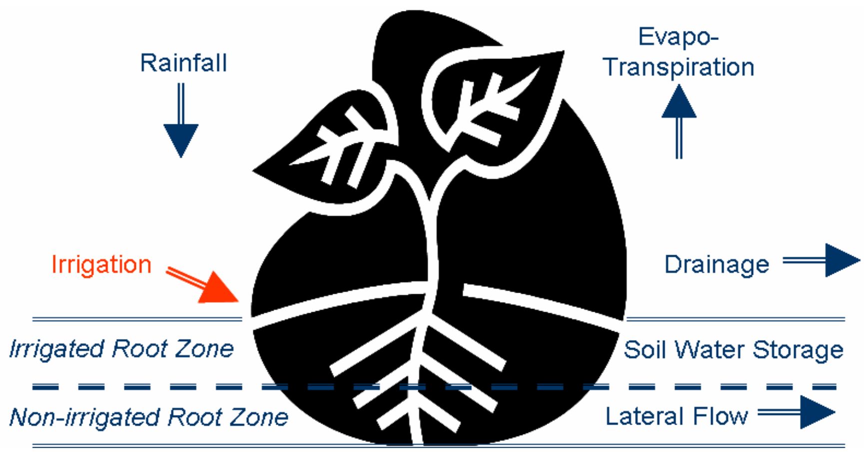

Figure 3.3.2.1 AFSIRS/WATBAL Conceptualization at Field Scale

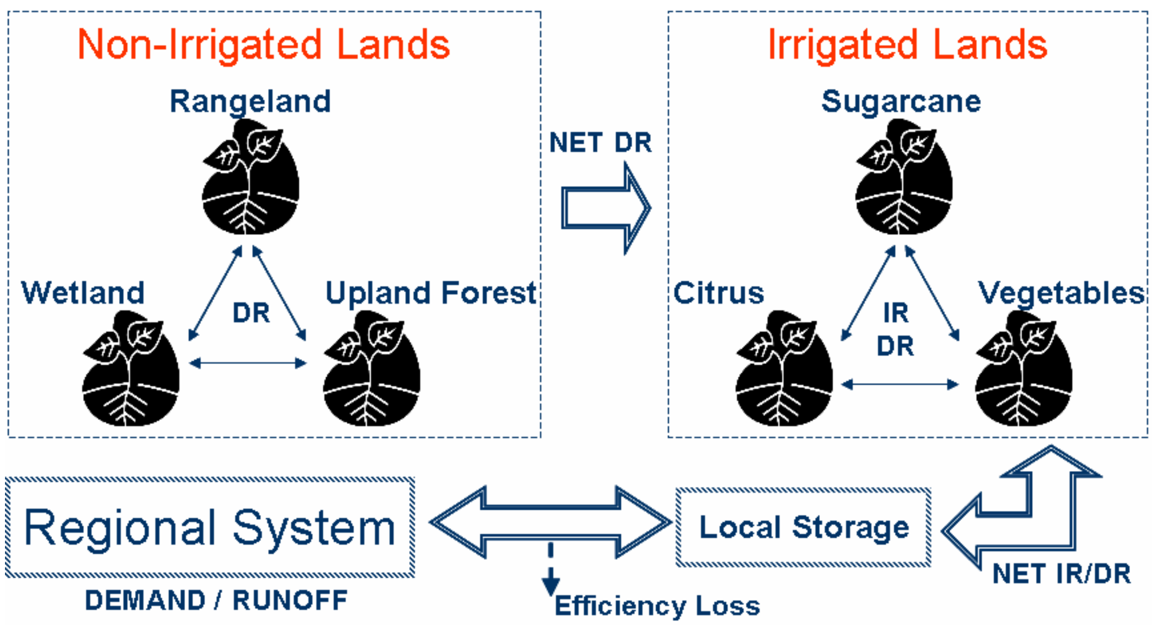

Figure 3.3.2.2 AFSIRS/WATBAL Conceptualization of Field Scale to Basin Scale Translation (DR = Field Scale Drainage, IR = Field Scale Irrigation)

The water budget equation for Figure 3.3.2.1 is:

$$\Delta Sto = Rain + IRR - ET_c - DR - LF \quad (3.3.2.1)$$

where:

ΔSto = Change in soil moisture
Rain = Effective rainfall
IRR = Irrigation requirement, including crop-specific efficiency loss
ET_c = Total ET for a particular crop types
DR = Drainage from the soil column
LF = Lateral flow groundwater lost from root zone (assumed to be zero).

The lateral flow is assumed to be zero since unsaturated zone flows are negligible and saturated zone flows are highly variable depending on local conditions. The inclusion of efficiency in the irrigation term is assumed to account for any lateral flows not considered. During wet periods, the soil moisture will increase to a point (SMAX) where rain, in excess of crop ET, will become runoff. During dry times, the soil moisture will decrease to a point (SMIN) were irrigation, supplemental to any rainfall, is required to meet the crop ET.

The AFSIRS/WATBAL water budget modeling for a given basin has three primary components (Figure 3.3.2.3): AFSIRS, WATBAL and AFSIRS Water Budget, as well as a central location for common data (RF_PET_LU_inputs). AFSIRS calculates irrigation requirements for cropland. The AFSIRS Water Budget spreadsheet was developed to calculate and route runoff and ground water components for AFSIRS. The WATBAL spreadsheet calculates the hydrology of nonirrigated land. Further details related to each of these components are available in the appendix to the CWMP. Depending on whether the model is applied as a single basin implementation or a multiple basin implementation, additional complexity can be added in the form of additional spreadsheets to control the routing from one basin to another.

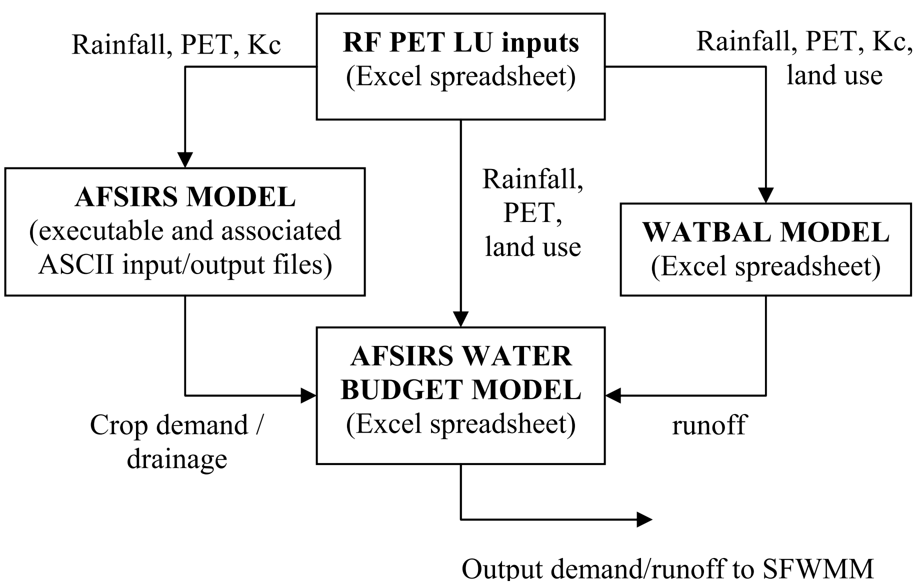

Figure 3.3.2.3 Single Basin Implementation of AFSIRS/WATBAL

3.3.3 Caloosahatchee and S4 Basins

The Caloosahatchee implementation of the AFSIRS/WATBAL model is conceptualized as a four basin model covering the lands between S-77/S-235 and S-79 that influence the regional system. These basins are defined as East Caloosahatchee-ground water irrigated (ecal-gw), East Caloosahatchee-C43 irrigated (ecal-d), West Caloosahatchee-ground water irrigated (wcal-gw), and West Caloosahatchee-C43 irrigated (wcal-d). The break between the "East" and "West" basins occurs at S-78. As previously mentioned, the multi-basin conceptualization of the model requires the addition of spreadsheets to handle the routing between basins. In addition to this need, the Caloosahatchee basin has the supplementary consideration of public water supply withdrawals from the Caloosahatchee canal (Lee County and Ft Meyers) and deliveries from the regional system (Lake Okeechobee, Caloosahatchee reservoir, ASR, etc.) to supplement agricultural and public water supply withdrawals. The final model conceptualization accounting for all of these considerations is presented in Figure 3.3.3.1. Calibration results for this basin are presented in Section 4.3.

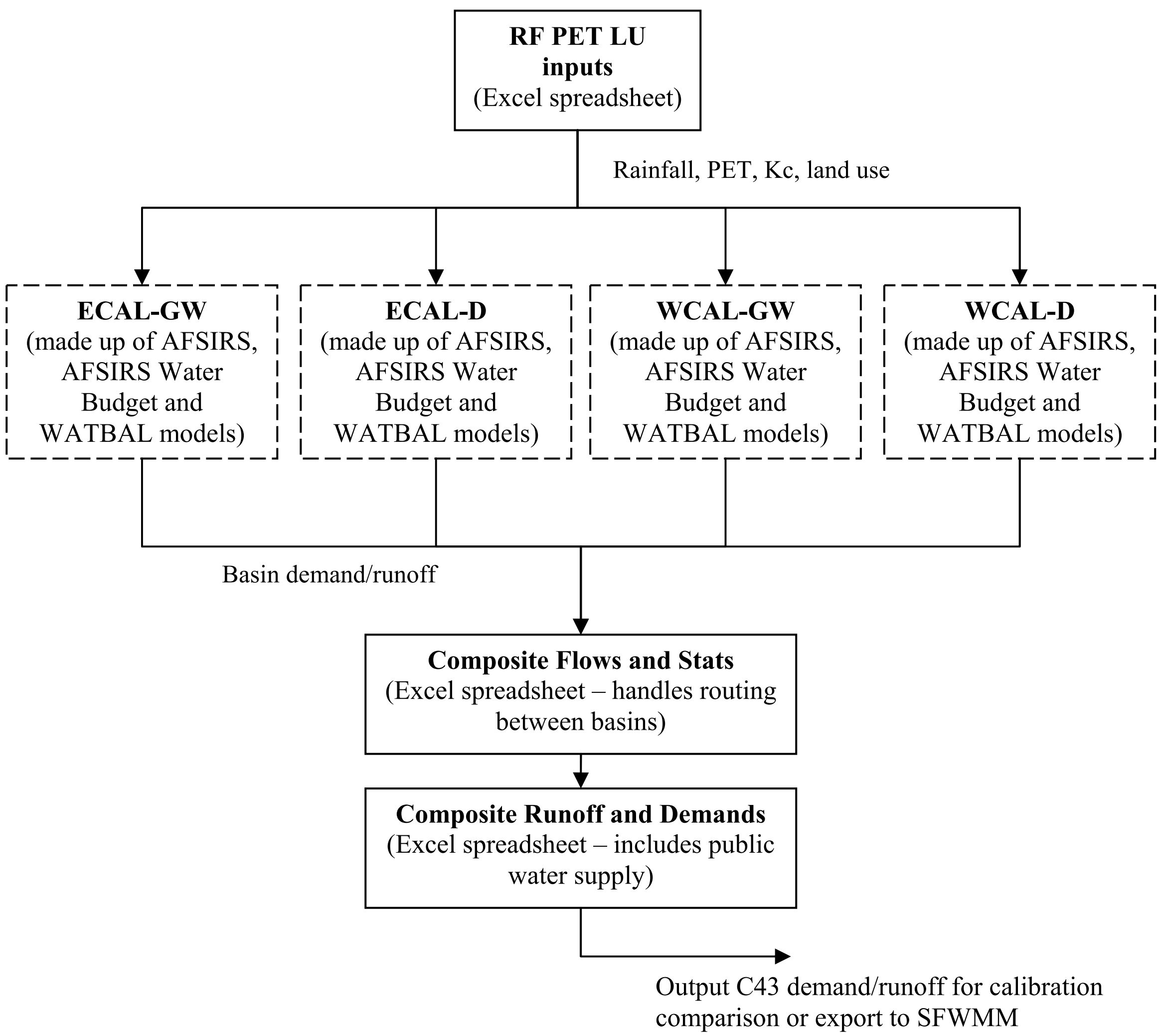

Figure 3.3.3.1 Caloosahatchee (C43) Basin Implementation of AFSIRS/WATBAL

In the SFWMM, the S4 basin is treated in a manner similar to the Caloosahatchee – as an external "bucket" to LOK. An additional level of complexity is also added due to the fact that a physical connection exists between the S4 and Caloosahatchee basin via the S235 structure and the 9-mile canal (to Lake Hicpochee). In order to give users the flexibility to model impacts due to these connections, the S4 Basin is modeled as the combination of two separate basins: S4_Diston (portion of S4 basin that has a physical connection to the Caloosahatchee basin) and S4_Other. Input options give flexibility in modeling the interaction between the S4 basin and the Caloosahatchee Basin via both S235 and the 9-mile canal, allowing the user to input appropriate routing and conveyance limitations depending on the scenario to be modeled.

As illustrated in Section 3.1, the SFWMM has the capability to simulate proposed storage features in the C43 basin. These components interact with the demand/runoff values generated by AFSIRS/WATBAL to help simulate regional routing of basin water. Excess runoff can be captured by the C43 reservoir and then later released to meet water supply needs in the basin or the downstream estuary. Above-ground storage features are simulated as independent features with their own water budgets including rainfall and ET processes. In order to preserve the overall basin water budget, AFSIRS/WATBAL estimates of excess runoff are lowered when above-ground reservoirs are simulated. This area-weighted adjustment helps to avoid double accounting of rainfall and ET within the overall basin boundary.

The calibration of the Caloosahatchee Basin is presented in Section 4.1. The calibrated parameters for the Caloosahatchee Basin were used for the other LOSA basins. The results are also presented in Chapter 4.

3.3.4 St. Lucie Basin and FPL Reservoir

For consistency's sake, modeling of the St. Lucie basin demand/runoff time series was estimated using the AFSIRS/WATBAL model as with the other LOSA basins outside the gridded SFWMM domain. Similar capabilities exist in the SFWMM for simulating reservoir and ASR interactions with the St. Lucie as those previously outlined for the Caloosahatchee basin. Explicit accounting of Lake Okeechobee deliveries is also considered in the SFWMM to maintain stages in the Florida Power & Light (FPL) Reservoir at Indiantown. While in reality, flows to the FPL reservoir are sent from Lake Okeechobee through the S-308 structure (and the C-44 canal) into the S-153 basin, the SFWMM assumes that these deliveries are made directly from the Lake to FPL. This simplifying assumption is made since the magnitude of these discharges is very small relative to the capacity of the S308 structure.

3.3.5 Lower Istokpoga Basins

In SFWMM v5.5, the Lower Istokpoga Basin is split into two basins. These basins are defined as: Lower Istokpoga Above Brighton (ISTOKPAB) and Lower Istokpoga Below Brighton (ISTOKPBB). This is necessary due to the fact that the Lower Istokpoga Above Brighton basin is subject to the combined conveyance limitation of the G207 and G208 pump capacities (270cfs). These pumps serve both the Brighton Seminole Reservation and the agricultural land above S71/S72 and below S70/S75. In the SFWMM, Brighton Tribal demands have first priority in water supply deliveries. Unmet demands in the Lower Istokpoga Above Brighton basin accrue from one time step to the next until sufficient conveyance exists to make deliveries. Demand/runoff time series are estimated using AFSIRS/WATBAL for these basins.

3.3.6 North and Northeast Lake Shore Basins

The North and Northeast Lake Shore basins have relatively small areas of irrigated lands compared to several of the other LOSA basins. However, in order to account for all LOSA agriculture, it was necessary to explicitly model these basins in SFWMM v5.5. The North Lake Shore basin, as modeled, has a relationship to the previously described Taylor Creek/Nubbin Slough (TCNSQ) inflow term. NLKSHORE demand/runoff goes through either S133 (only runoff) and/or S193. This is an issue since a portion of the runoff that goes through S-133 is already quantified in the SFWMM as part of the TCNSQ (S133 + S191) inflow term. To avoid any double accounting, an additional term TCNSQ_REV was derived. TCNSQ_REV is defined as the portion of the TCNSQ term which comes from tributary basins upstream of the North Lake Shore. This upstream flow enters the North Lake Shore Basin and is effectively reduced (on days with NLKSHORE demands) or increased (on days with NLKSHORE runoff), resulting in the "at Lake" TCNSQ observed flow. This relationship is illustrated in Figure 3.3.6.1. At run-time, SFWMM V5.5 reads both the TCSNSQ and TCNSQ_REV term and then internally adjusts the NLKSHORE demand and runoff terms to ensure that the LOK budget is correctly accounted and that model output reflects TCNSQ as it is read in from the input file.

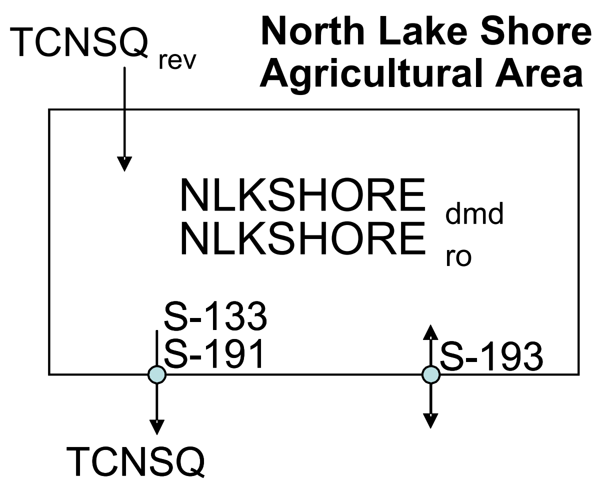

Figure 3.3.6.1 Relationship between TCNSQrev, TCNSQ and NLKSHOREdmd/ro

3.3.7 Seminole Brighton and Big Cypress Reservations

The Seminole Brighton Reservation is located in the Lower Istokpoga Basin northwest of Lake Okeechobee. Following the Brighton / Istokpoga calibration exercise outlined in Section 4.3, the AFSIRS/WATBAL model was run using calibrated parameters and land use as defined in the Work Plan authorization outlined in the letter from Lewis, Longman & Walker (2000). These demand estimations as modeled were consistent with water rights compact entitlement volumes protected by Florida state law. A daily time series of Brighton Reservation demand was calculated for the period 1965-2000. This time series was then modified by a rescaling program which imposes a daily maximum of 530 ac-ft (the combined conveyance of the G207 and G208 pump stations) and attempts to obtain an annual average of 28,500 ac-ft over the period of simulation (consistent with release volumes over the last several years). While the impact of this rescaling was large in previous modeling efforts, the calibration exercise for the Brighton / Istokpoga area reduced the impact of rescaling, effectively making the program only a check on conveyance limitations. Results of the rescaled time series are presented in Table 3.3.7.1. As can be seen the 2/10 monthly demand in the time series is in agreement with (and actually exceeds) the entitlement delivery requirement for the Brighton Reservation.

Table 3.3.7.1 Comparison of Modeled Demands to Work Plan Entitlement for Seminole Brighton Reservation

As modeled with AFSIRS/WATBAL and rescaling for 1965-2000 period.	Average Annual Demand (ac-ft)	28500
	Max Monthly Demand (ac-ft)	10348
	Max Monthly Demand (mgm)	3374
	Monthly 2/10 Demand (mgm)	**2383**
From Work Plan 2/10 Demand (mgm)		**2262**

The Seminole Big Cypress Reservation is incorporated in the SFWMM using a pre-processed lumped water-budget modeling approach consistent with the modeling of other non-EAA LOSA basins and the Seminole Brighton Reservation. Following the basin calibration exercise outlined in Section 4.3, a 36-year continuous time-series (1965-2000) of daily basin-scale irrigation demands is estimated using the AFSIRS-WATBAL basin-scale water budget model with 2000 Work Plan landuse estimates provided by the Seminole Tribe. Deliveries to meet estimated supplemental Seminole Big Cypress demands come from several regional sources. In order of priority, regional water is available from STA 6, Rotenberger Wildlife Management area and Lake Okeechobee via the Miami canal/G404. Results of the Seminole Big-Cypress demand estimation effort are presented in Table 3.3.7.2.

Table 3.3.7.2 Comparison of Modeled Demands to Work Plan Entitlement for Seminole Big Cypress Reservation

As modeled with AFSRIS/WATBAL for 1965-2000 period.	Average Annual Demand (ac-ft)	28509
	Max Monthly Demand (ac-ft)	10694
	Max Monthly Demand (mgm)	3486
	Monthly 2/10 Demand (mgm)	**2659**
From Work Plan 2/10 Demand (mgm)		**2606**

While estimated supplemental demands for the Seminole Reservations, and therefore deliveries, for every month of simulation do not equate to monthly entitlement quantities, tribal rights to these quantities are preserved.

3.3.8 Supply-Side Management for LOSA

The guiding policy for implementation of agricultural water shortage restrictions for the Lake Okeechobee Service Area is the Supply-Side Management (SSM) plan. In contrast to the WSE schedule, SSM is used to manage lower stages in Lake Okeechobee (Figure 3.3.8.1). The zone below the "SSM Trigger Line" identifies when water shortage restrictions will be imposed within LOSA. Under the SSM methodology, the amount of water available to users of Lake Okeechobee water is defined as allocable volume and is a function of available storage within the lake in conjunction with expected net losses. The allocable volume of water is dependent on both expected climatic conditions and on a projected lake stage at the end of the dry season, known as the Reference Elevation. Temporal allocation of water under SSM is designed to avoid lake levels lower than the reference elevation at the end of the dry season, although this may not be prevented depending upon the severity of the drought.

Supply-Side Management represents a complicated calculation scheme with consideration for many factors. Included in the determination of SSM output are terms that consider LOSA current and projected demand, the deliveries made to non-LOSA water supply users, temporal distribution patterns of demand through the calendar year, and projected changes in lake storage (from net rainfall and inflows).

The end result of the SSM algorithm during periods of water shortage is a cutback fraction that is applied by default to all LOSA basins and that can be optionally applied to Seminole Tribal demand and environmental water supply depending on user input. This cutback fraction will allow only a portion of the supplemental irritation demand for a basin to be delivered. The model has the capability to apply a global maximum cutback fraction (e.g. provide a minimum level of service to consumptive users not to exceed 50% cutback) or to impose a phased cutback approach based on drought severity (e.g. apply a maximum cutback of 15% for a mild drought or 60% for a severe drought). Details on how the SFWMM handles the specifics of the SSM calculation are available in Appendix F1.

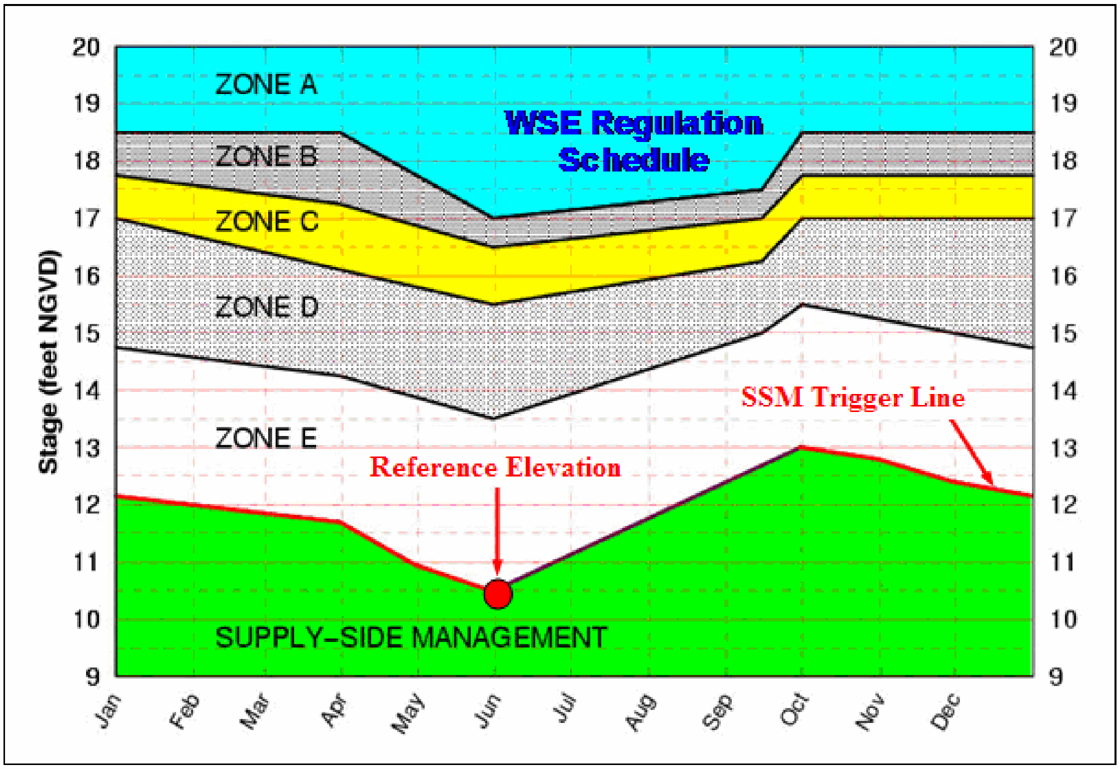

Figure 3.3.8.1 Lake Okeechobee Regulation Schedule with Supply-Side Management Line